1.0 INTRODUCTION

The U.S. Department of the Interior (USDOI), Minerals Management Service (MMS) funded the project titled "Environmental Surveys of Potential Borrow Areas on the Central East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration." This document is the Technical Report for the project.

1.1 BACKGROUND

1.1.1 Coastal Interests in OCS Sand

The Federal Outer Continental Shelf (OCS) contains large sand deposits that are expected to serve as long-term sources of borrow material for beach nourishment and coastal restoration projects. Potential for exploitation of these resources has grown rapidly in the last several years with identification of suitable sand resource areas in some OCS regions. Demand for high quality sand suitable for beach nourishment, coastal protection, and other public and private projects is anticipated to increase during coming years.

Considering future beach nourishment needs, renourishment maintenance cycles, and anticipated storms, coastal jurisdictions recently have become more interested in sand resources seaward of State waters for several reasons. There is increasing awareness that sand is a valuable resource and should be carefully managed as such. Onshore sources of suitable sand that were once abundant are becoming scarce due to deposit depletion, competing uses, and urban development. For ambitious nourishment projects, transporting sand from nearshore areas was found to be far more economical than trucking sand from upland sources (Freedenberg et al., 1995b). Like onshore sources, nearshore sand resources often are limited, diminishing in supply, and/or polluted, necessitating the need for alternative deposits that exist farther offshore. Using offshore deposits provides the important benefit of adding sand to the beach/nearshore system, rather than simply moving sand from one part of the system (nearshore) to another (beach). Furthermore, sand resources in Federal waters may be environmentally preferable due to concerns that extraction of large quantities of sand and gravel from nearshore sites can change the bathymetry of an area and result in modifications to existing physical oceanographic conditions. In relatively shallow nearshore waters, alterations to local current and wave regimes can have drastic consequences in terms of erosion and accretion. From a biological standpoint, excavation of sand resource areas farther from the shoreline may prove to have less adverse impacts on essential fish habitats than sites closer to shore (Jordan, 1999).

1.1.2 MMS Activities

The MMS is responsible for managing exploration and development of mineral resources on submerged Federal OCS lands. Among MMS missions is the need to develop approaches for managing the Nation's OCS mineral resources in an environmentally sound

and safe manner. The MMS has a strong environmental mandate and is required to conduct environmental studies to obtain information useful for decisions related to marine mineral activities. Guidelines for protecting the environment stem from a wide variety of laws, including the OCS Lands Act, National Environmental Policy Act (NEPA), Endangered Species Act (ESA), Marine Mammal Protection Act, National Historic Preservation Act, Clean Water Act, Magnuson-Stevens Fishery Conservation and Management Act (Sustainable Fisheries Act), and others. Existing rules and regulations governing domestic marine mining provide a framework for comprehensive environmental protection during prospecting and scientific research activities and post-lease operations (e.g., 30 Code of Federal Regulations [CFR] Parts 280, 281, and 282).

Anticipating that requests for sand will increase significantly due to beach nourishment and storm protection needs, the MMS is ensuring that environmental management processes will be expedited when OCS sand resources are most needed. Under Public Law 103-426, the MMS has authority to convey rights to OCS sand, gravel, or shell resources for shore protection, beach or wetland restoration projects, or construction projects funded in whole or part or authorized by the Federal Government. As a result of the Water Resource Development Act of 1999, the MMS does not assess fees to any State or local government agency for OCS sand used in beach nourishment, shore protection, or coastal wetland restoration projects (MMS, 1999b), which furthers coastal interests in OCS sand. The MMS has provided Federal sand for beach nourishment projects in Florida, Louisiana, Maryland, New Jersey, and Virginia.

The MMS has been working with coastal States along the Atlantic Ocean and Gulf of Mexico to identify sand resources. Cooperative agreements and matching funds have allowed the MMS and States to conduct geological studies focused on locating sand sources that are compatible for beach nourishment and storm protection projects.

The MMS also has funded physical/biological studies offshore coastal States so that environmental information is available in a timely manner for prudent decisions regarding sand resources. Results will be used by the MMS to fulfill its environmental requirements when specific requests for Federal sand are received from States, local jurisdictions, or other Federal agencies.

1.1.3 MMS and State of Florida

The MMS has been actively working with the State of Florida to identify and convey OCS sand for beach nourishment. The MMS initiated a Federal/State partnership in July 1994 with the State of Florida to identify offshore areas that may contain sand resources suitable for beach nourishment (MMS, 1999a). The MMS has conveyed OCS sand to Brevard County, Duval County, and Patrick Air Force Base (Hartgen, 2001).

The MMS and State of Florida also cooperated in an outreach effort directed at organizations involved in beach nourishment and coastal issues. A panel presentation titled “Interagency Cooperation Regarding Offshore Sand Resources” occurred 3 February 2000 at the 13th Annual National Conference on Beach Preservation Technology in Melbourne, Florida. Presentations were given by the MMS titled “A Biological/Physical Dredging Impact Study Offshore Central Florida” (Drucker, 2000) and by the Florida Geological Survey (FGS) titled “Preliminary Identification of Sand Resources in Federal Waters Along the Central Florida East Coast” (Freedenberg et al., 2000a).

The MMS and FGS have been focusing on the geology of a region 3 to 8 miles offshore of Brevard, Indian River, St. Lucie, and Martin Counties along the central east coast of Florida. Over 58 miles of sandy beaches are eroding along this 90-mile stretch of coastline (MMS, 1999a). Reports for Years 1 (Freedenberg et al., 1995a,b; Hoenstine et al., 1995), 2 (Freedenberg et al., 1997), 3 (Freedenberg et al., 1999), and 4 (Freedenberg et al., 2000b) have resulted from the MMS/FGS efforts. The goal of the multi-year cooperative agreement was to locate OCS sands suitable for beach restoration (Freedenberg et al., 2000a). Results of the FGS investigations were intended to form the geological basis for conducting the physical/biological study, which is the topic of this document, to evaluate potential impacts from dredging in sand resource areas.

1.2 STUDY AREA

The study area for the physical/biological project encompassed OCS waters seaward of the Federal/State boundary offshore of Brevard, Indian River, St. Lucie, and Martin Counties (Figure 1-1).

1.3 STUDY PURPOSE AND OBJECTIVES

The MMS specified the purpose and objectives of this physical and biological study. The primary purpose of the study was to address environmental concerns raised by the potential for dredging OCS sand offshore the central east coast of Florida and to document the findings in a technical report. Environmental information was collected and compiled to assist the MMS in making future decisions relative to negotiated agreements (non-competitive leases), NEPA documents (Environmental Assessments and Environmental Impact Statements), and other regulatory requirements concerning Federal sand deposits off Florida.

Primary environmental concerns focused on physical and biological components of the OCS environment. To this end, the MMS identified five study objectives at the beginning of the project:

Physical Objectives

- Wave Modifications: Evaluate potential modifications to waves and currents in the study area due to offshore dredging within potential sand resource areas.
- Sediment Transport Patterns: Evaluate impacts of dredging in Federal waters and consequent beach nourishment in terms of potential alterations in sediment transport patterns and sedimentary environments, and impacts to local shoreline processes.

Biological Objectives

- Benthic Ecological Conditions: Characterize benthic ecological conditions in and around potential sand resource areas identified by the MMS/FGS cooperative effort.
- Benthic Infaunal Evaluation: Evaluate benthic infauna resident in potential sand resource areas and assess potential effects of offshore dredging activity on these organisms, including an analysis of recolonization periods and success following cessation of dredging activities.
- Project Scheduling Considerations: Evaluate times for dredging in the sand resource areas relative to transitory pelagic species.

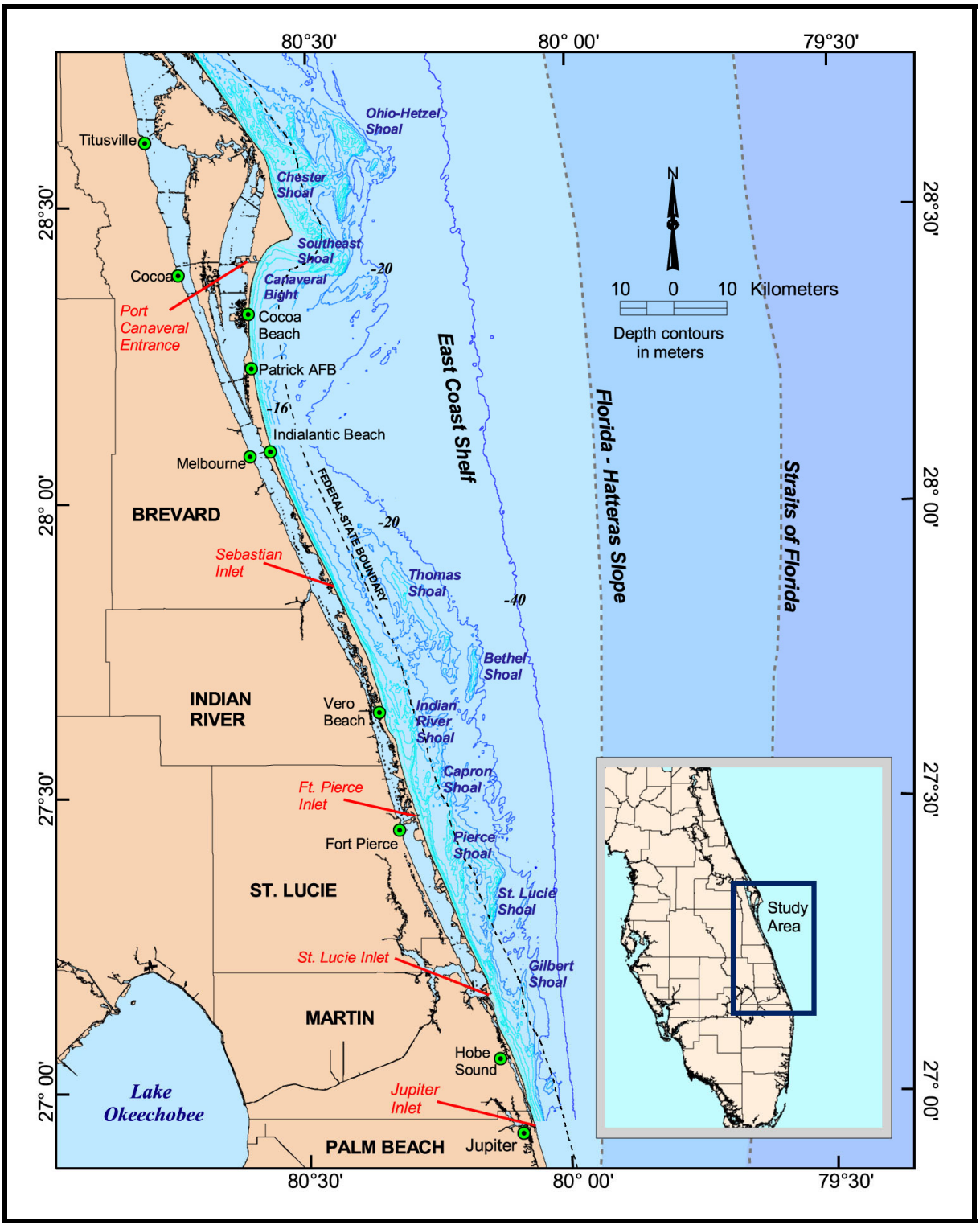

Figure 1-1. Central east Florida study area and key geographical features.

1.4 STUDY APPROACH

1.4.1 Sand Resource Area and Borrow Site Locations and Characteristics

Since 1994, the MMS has provided funds to the FGS to collect seismic, grab, and vibracore data for the purpose of identifying sources of sand in Federal waters offshore Martin, St. Lucie, Indian River, and Brevard Counties (see Section 1.1.3). In 2000, the MMS requested that the FGS provide recommendations for potential sand resource areas offshore the four counties based on geological study results and best available information, even though additional geological sampling and interpretation may be needed in the future. The FGS subsequently identified eight sand resource areas that formed the basis for conducting this physical/biological study (Figure 1-2). Areas A1 and A2 were offshore Brevard County near Cape Canaveral, Areas B1 and B2 were offshore of the line between Brevard/Indian River Counties, Areas C1 and C2 were offshore of the line between St. Lucie/Martin Counties, and Areas D1 and D2 were offshore south Martin County.

In 2001, the MMS requested that a ninth sand resource area be included only as part of the biological studies. This ninth sand resource area is referred to as Area A3 in this report. Area A3 is located inshore of Area A2, is just seaward of the Federal-State boundary, and is small relative to the other eight sand resource areas (Figure 1-2). As directed by the MMS, biological surveys were conducted in and near these nine sand resource areas to characterize benthic ecological conditions. Because monitoring surveys of actual sand mining operations were not to be conducted, the biological assessment was based only on the field characterization surveys and existing literature.

In contrast to the biological studies, the MMS requested that the physical processes studies focus on borrow sites within sand resource areas where compatible sand characteristics and appropriate sand volumes were available to meet local beach nourishment requirements. Six potential sand borrow sites within five of the nine resource areas (Figure 1-2) were evaluated to determine the potential impacts of offshore sand mining for beach replenishment (see Section 7.0). Although Areas A1, B1, B2, C1, and D2 were designated as ones with greatest potential, it is possible that sand could be dredged from intervening offshore sites. Borrow sites in Areas A2, A3, C2, and D1 were not included in the physical processes analyses. For Area A2, no shoals are present on the seafloor, signifying low priority as a sand borrow site. As long as numerous sand shoals exist as potential borrow sites within the geographical area, it is recommended that holes not be excavated on the shelf surface. Area A3 was selected for biological analyses only. In Area C2, the quantity of sand available for beach nourishment is small (<1 million cubic meters [mcm]) relative to basic replenishment needs. At Area D1, water depths are in excess of 30 m, making potential dredging operations more complicated and costly. For the remaining potential sand resource areas, each has specific geological and geographical characteristics that make it viable as a sand target for specific segments of coast. These sand resource areas are very similar geologically (medium-to-coarse sand size ridge deposits with relief of 2 m or more and resource volumes of at least 1 mcm).

The amount of dredging that occurs at any site is a function of Federal, State, and local requirements for beach replenishment. It is nearly impossible to predict the exact sand quantities needed in the foreseeable future, so a representative value for any given project was estimated based on discussions with MMS and State personnel. Preliminary analysis of short-term impacts (storm and normal conditions) at specific locations along the coast

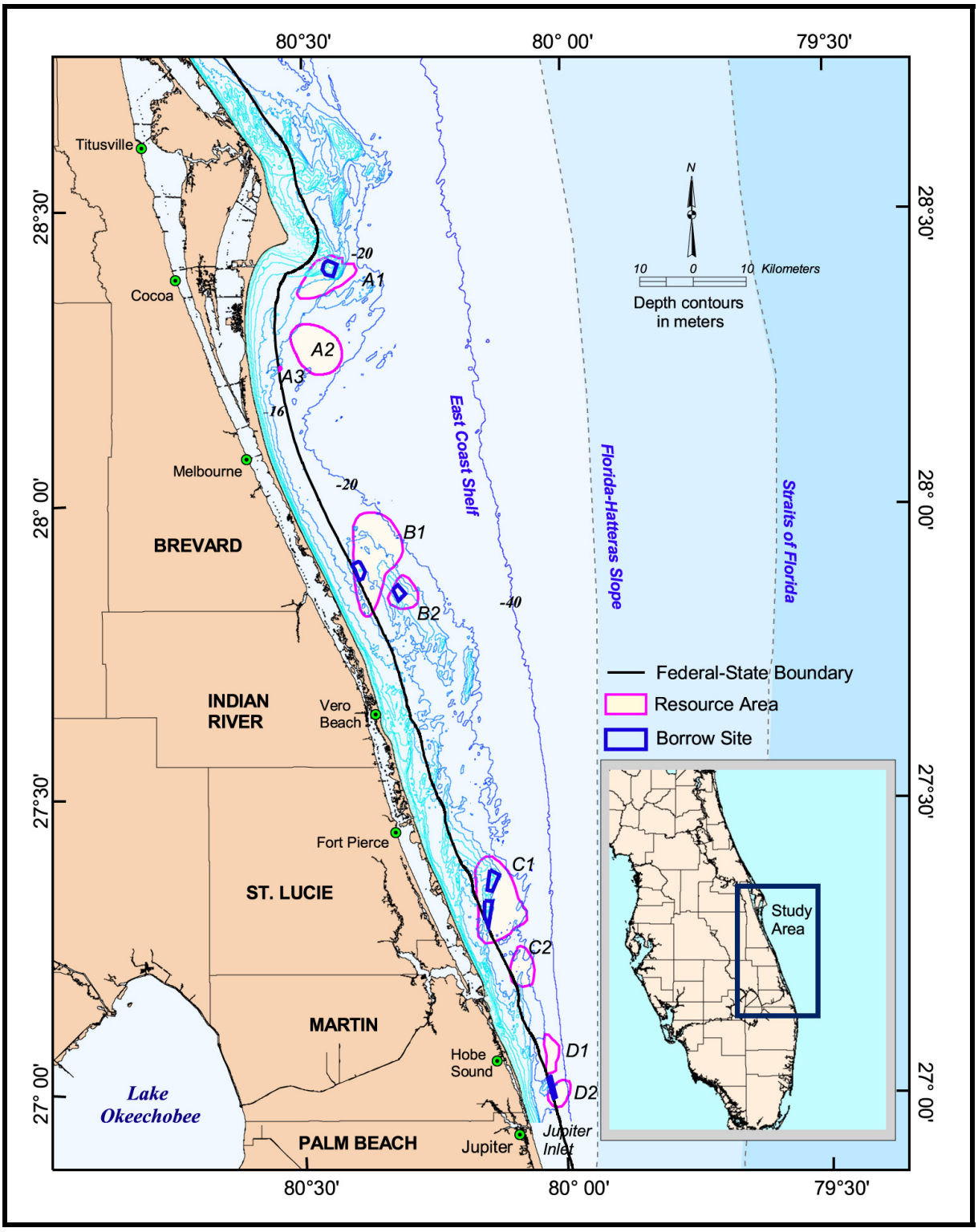

Figure 1-2. Sand resource areas and borrow sites relative to the Federal-State boundary.

landward of sand borrow sites indicates that about 1 mcm of sand could be needed for a given beach replenishment event. Long-term shoreline change data sets indicate that a replenishment interval of about 10 to 30 years would be expected to maintain beaches. This does not consider the potential for multiple storm events impacting the coast over a short time interval, nor does it consider longer time intervals without destructive storm events. Instead, the estimate represents average change over decades that is a reasonable measure for coastal management applications.

Given the quantity of 1 mcm of sand per beach replenishment event, the surface area covered for evaluating potential environmental impacts is a function of average dredging depth. Two factors should be considered when establishing dredging practice and depth limits for proposed extraction scenarios. First, regional shelf sediment transport patterns should be evaluated to determine net transport directions and rates. It is good sand resource management practice to dredge the leading edge of a migrating shoal because infilling of dredged sites occurs more rapidly at these locations (Byrnes and Groat, 1991; Van Dolah et al., 1998). Second, shoal relief above the ambient shelf surface should be a determining factor controlling depth of dredging. Geologically, shoals form and migrate on top of the ambient shelf surface, indicating a link between fluid dynamics, sedimentology, and environmental evolution (Swift, 1976). As such, average shoal relief is a reasonable threshold for maintaining environmentally-sound sand extraction procedures.

For sand resource areas within the study area, maximum shoal relief was on the order of 5 to 6 m, and average shoal relief was about 2 to 3 m. Although modern beach replenishment practice varies depending on geographical location and level of funding for the central east Florida coast, it is reasonable to expect multiple replenishment events over the next 50 years from the designated sand resource areas. As such, one shoal deposit was selected from each resource area based on geological characteristics. A maximum excavation depth was determined for each specific site. In Area A1, a 5.39×10^6 m^2 borrow site was defined based on shoal morphology (Figure 1-2). Bathymetric data and geological samples indicated a maximum excavation depth of 12 m, resulting in a 13.6 mcm extraction scenario; median grain diameter for the deposit is 0.32 mm (Table 1-1). The same procedure was used for borrow sites at the other selected sand resource areas. The borrow site in Area B1 encompassed 4.62×10^6 m^2 of seafloor to a depth of 15 m, resulting in 11.0 mcm of sand. The borrow site for Area B2 covers 3.48×10^6 m^2 of seafloor to a maximum excavation depth of 13 m, and it contains 7.6 mcm of sand. For the northern borrow site in Area C1 (C1 north), surface area encompassed 5.16×10^6 m^2. The maximum excavation depth was 12 m, resulting in 5.8 mcm of sand. The southern borrow site in Area C1 (C1 south) covers approximately 4.71×10^6 m^2 of seafloor. For an excavation depth of 12 m, the resulting sand volume is 8.8 mcm. For the southernmost sand resource area (D2), the sand borrow site is quite small at approximately 2.25×10^6 m^2 of seafloor. For an excavation depth of 20 m, the resulting sand volume is 4.1 mcm. Sand volume at each of these borrow sites is at least equal to the quantity of sand needed for any single expected replenishment event, so wave and sediment transport analyses were used to estimate potential cumulative effects of multiple extraction scenarios.

Table 1-1. Sand resource characteristics at potential borrow sites in resource areas offshore central east Florida.

Borrow Site	Borrow Site Surface Area (x 10^6 m^2)	Maximum Excavation Depth (m)	Borrow Site Sand Volume (x 10^6 m^3)	D10 (mm)	D50 (mm)	D90 (mm)
A1	5.39	12	13.6	0.70	0.32	0.21
A2	No Shoals	No Shoals	No Shoals	-----	-----	-----
A3	Biology Only	Biology Only	Biology Only	-----	-----	-----
B1	4.62	15	11.0	1.15	0.60	0.28
B2	3.48	13	7.6	1.49	0.47	0.25
C1 (north)	5.16	12	5.8	1.96	0.61	0.26
C1 (south)	4.71	12	8.8	0.62	0.29	0.18
C2	Too Small	Too Small	Too Small	-----	-----	-----
D1	Depth Limited	Depth Limited	Depth Limited	-----	-----	-----
D2	2.25	20	4.1	0.59	0.31	0.20

D10 = grain diameter above which 10% of the distribution is retained; D50 = median grain diameter; D90 = grain diameter above which 90% of the distribution is retained

1.4.2 Wave Modifications

The goal of this study element was to perform wave transformation numerical modeling to predict the potential for adverse modification of waves resulting from sand dredging operations. Changes in bathymetry in sand borrow sites can cause wave energy focusing, resulting in substantial alterations in sediment transport at the site of dredging operations, as well as along the shoreline landward of borrow sites. Because the purpose of dredging offshore sand from a specific site will be driven by the need for beach replenishment, it is critical to understand the impact of changing wave transformation patterns on shoreline response before potentially exacerbating a problem. Numerical comparisons of existing conditions and post-dredging impacts provided a means of documenting modifications to waves as they crossed the sand resource areas.

1.4.3 Sediment Transport Patterns

The goal of this study element was to predict changes in sediment transport patterns resulting from sand dredging operations using numerical information generated from wave transformation modeling, combined with offshore current data. Because localized flow patterns over shoals may have significant impact on ecological conditions in the offshore sand resource areas, total currents were measured east of Sebastian Inlet at Areas B1 and B2 using an Acoustic Doppler Current Profiler (ADCP). Existing current measurements were analyzed to document temporal variations in flow throughout the study area, whereas ADCP measurements were used to examine spatial variations throughout the water column (detailed in Section 5.0). Sediment transport rates were quantified for sand borrow sites using an analytical approach, whereas transport rates at the shoreline were determined numerically using output from wave transformation numerical modeling.

Historical shoreline and bathymetric data were compiled to document regional sediment transport patterns over a 40- to 50-yr time period. Net changes in sediment erosion and deposition on the shelf surface provided a direct method for identifying patterns of sediment transport and quantifying net rates of change throughout the sand resource

areas. These data also were used to verify numerical results for direction and magnitude of sediment transport.

1.4.4 Benthic Ecological Conditions

The goal of this study element was to characterize benthic ecological conditions in and around the sand resource areas. Existing literature and data were searched, collected, analyzed, and summarized to characterize the ecological environment and to form the foundation for biological field survey design. Biological field surveys were conducted to characterize infauna, soft bottom epifauna and demersal fishes, hard bottom epibiota and demersal fishes, sediment, and water column parameters.

1.4.5 Benthic Infaunal Evaluation

The goal of this study element was to assess potential effects of offshore dredging on benthic infauna and analyze recolonization periods and success following cessation of dredging activities. Existing literature and data on dredging effects were used in conjunction with biological field survey results to examine potential benthic effects and recolonization in the sand resource areas. Monitoring surveys of actual sand mining operations were not to be conducted in the areas to determine impacts.

1.4.6 Project Scheduling Considerations

The goal of this study element was to evaluate times for offshore dredging relative to pelagic species. Environmental windows are temporal constraints placed on dredging activities to protect biological resources from potentially detrimental effects (Dickerson et al., 1998). Existing information concerning seasonal occurrence of pelagic species and potential impacts from dredging was used to evaluate project scheduling considerations for pelagic fishes, sea turtles, and marine mammals.

1.5 DOCUMENT ORGANIZATION

This document was organized into nine major sections as follows:

- Introduction
- Environmental Setting
- Regional Geomorphic Change
- Assessment of Wave Climate Impact by Offshore Borrow Sites
- Circulation and Offshore Sediment Transport Dynamics
- Biological Field Surveys
- Potential Effects
- Conclusions
- Literature Cited

In addition to the main document, appendices were prepared in support of many analyses presented in the report. Furthermore, an Executive Summary, a Technical Summary, and a Non-Technical Summary will be prepared as separate documents to provide brief study descriptions for audiences including managers, researchers, and the general public.